ISTANBUL BILGI UNIVERSITY

MSC IN ECONOMICS

THE PHILLIPS CURVE IN BRAZIL, 2004 – 2014

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ISTANBUL, TURKEY

2015

THE PHILLIPS CURVE IN BRAZIL, 2004 - 2014

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Date of Thesis Approval: 14/01/2015

Total Number of Pages: 26

Key words

Phillips Curve, Brazil, Inflation, Unemployment, Natural Rate of Unemployment.

Abstract

In this study, we apply the Phillips Curve theory, of negative relationship between inflation and unemployment, to the Brazilian economy for the months between January of 2004 and January of 2014. In order to run the econometric calculation, we estimate the natural rate of unemployment within the model. The results indicate that for a certain period of time, the Phillips Curve relationship may be applicable to Brazil, and also that the natural unemployment rate was probably variable.

Acknowledgements

Firstly, I would like to thank my parents and family for their constant and unconditional support.

Secondly, I present my deepest gratitude to the professors of the Economics Department at Istanbul Bilgi University, for sharing their knowledge with me. I own special thanks to my advisor Engin Volkan, committee members Serda Selin Öztürk and Durmuş Özdemir, Professor Jean Laine and Deniz Nebioğlu.

Finally, I thank the support of Erkin, Melike, Bahadir and Fadime, who helped me to go through so many long study nights.

Table of Contents

I. Introduction

Inflation is a central issue in economic research and for policymakers. Financial institutions usually rely on the Phillips Curve and its negative relationship between inflation and unemployment in order to apply economic forecasting. In the case of the Brazilian economy, lack of consensus on the fit of the Phillips Curve indicates the need for further research on the correlation between inflation and unemployment. Thus, the aim of this study is to verify the applicability of the Phillips Curve to the Brazilian economy for the months between January, 2004 and January, 2014.

The standard econometric approach of the Phillips Curve in Brazil estimates inflation as a function of inflation expectations, wages multiplied by unemployment gap, marginal cost and a shock variable. Unemployment gap is, on its turn, the difference between unemployment rates and natural unemployment.

A challenge for the application of the Phillips Curve to Brazil is the non-availability of natural unemployment data. Since previous studies suggest that this component might be flexible, we generate a natural unemployment series with methodology from Portugal and Madalozzo (2000). Following these calculations, we make two different estimations of the Phillips Curve. The first one uses flexible natural unemployment rate and the second one is fixed at 6.5%, according to the estimation of The Central Bank of Brazil for May, 2012. This allows us to check the significance of the flexible and the fixed natural unemployment rates in our estimation and thereby contribute to the literature on this topic.

Still on the choice of variables, we use producer price index as a proxy for marginal cost. This is the first study of our knowledge that uses such index on the application of the Phillips Curve to Brazil. The proxy used for the shock variable is credit on the market, measured by interest rate gap, the difference between target interest rates and market interest rates.

This study contributes to the literature by showing that for a certain period of time the Phillips Curve relationship may be applicable to Brazil. Other additions are the profiling of natural rates of unemployment as flexible over time and suggesting producer price index as a proxy for marginal cost and of credit as a shock variable.

The study structure is as follows: in Section II, we present literature on inflation, Phillips Curve framework and its applications to Brazil. Section III demonstrates the econometric model and the methodology for calculating natural unemployment. Section

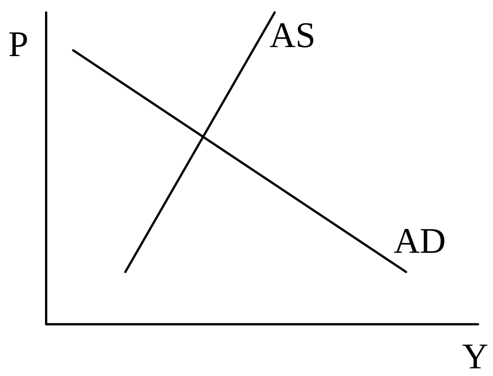
IV provides information on data sources and adjustments, calculation of unemployment gap and descriptive statistics. Estimation results are shown in Section V, followed by the conclusion of the paper.

II. Literature on Inflation

> *"Inflation and unemployment are two of the main subjects of macroeconomics. They are among the principal concerns of policy makers and the public, and they have been the subject of large amounts of research" Romer (1996), p. 388*

Inflation can affect opportunity cost of holding money, contract frequencies, indexation and investment. It also challenges financial planning and market expectations. Individuals may perceive it as reducing their well-being due to changes in nominal prices. Interpretation of high inflation variations can also be that the government lacks control of the economy.

The base of the analysis of inflation and its sources is the Aggregate Demand – Aggregate Supply model.



Prices rise with an increase in aggregate demand (AD) or a decrease in aggregate supply (AS). Aggregate demand shifts to the right when there are changes in monetary or fiscal policies. Aggregate supply (AS) decreases due to negative technology shocks, reduction of labor supply or shocks in relative costs.

Samuelson and Solow (1960) indicate an "identification problem", the difficulty in perceiving the causes of inflation. With aggregation of sectors of the economy, it is not possible to define if the inflation is demand or cost driven. Even with empirical analysis, separating the cause from the effect can be difficult. The lack of consensus on an initial standard would lead to a diffuse understanding on what factor leads to price change.

Inflation and Unemployment

The negative relationship between unemployment and wages was studied by Phillips' 1958 paper *"The Relation between Unemployment and the Rate of Change of Money Wage Rates in the United Kingdom, 1861 – 1957".* The author uses the separate periods from 1861 to 1913, from 1913 to 1948 and from 1948 to 1957 to verify the relationship between wages and unemployment in the United Kingdom.

Phillips (1958) suggests that the assumption that demand variations lead to price changes, should also be valid for the labor market. Here, prices represent the wages of the employees. When demand for labor is high, employees tend to force wage increases and firms offer higher wages than the market in order to attract talent. When there is low demand for labor and high unemployment, firms can only reduce wages gradually once workers will be unwilling to have a decrease in their income from work.

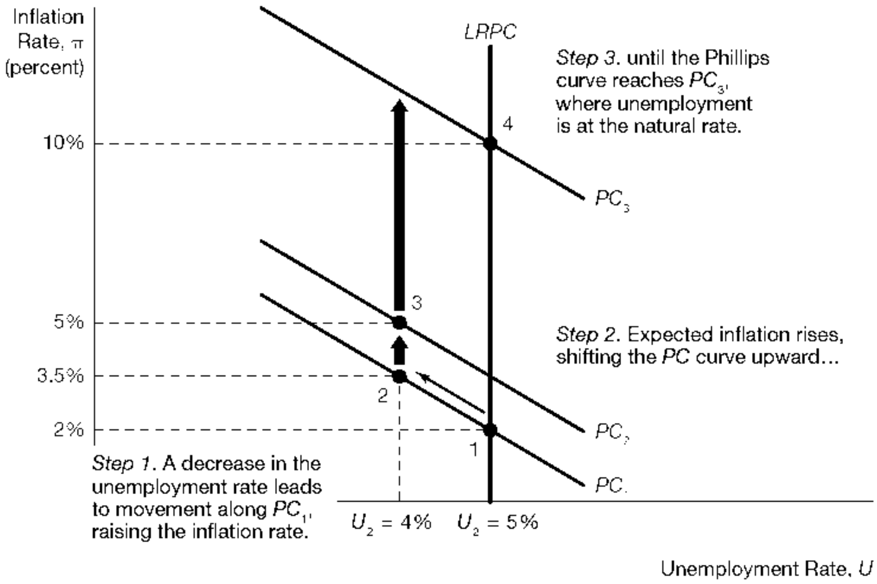
Phillips (1958) finds what he considers a typical pattern between change of wage and unemployment, where wages are higher with lower unemployment. This shows the existence of a negative relationship between wages and unemployment. The author concludes that the level of unemployment and its rate of change affect the rate of change of money wage rates.

Based on Phillips (1958), Samuelson and Solow (1960) conduct a similar study for United States data between 1933 and 1960. They find that, in line with Phillips, "wage rates do tend to raise when the labor market is tight, and the tighter the faster" (Samuelson and Solow, 1960).

Phelps (1967) argues that the Phillips approach towards inflation is purely statistical, which does not provide proper inference on the dynamic aspect of the trade-off between unemployment and inflation. Phelps (1967) and Friedman (1968) introduce the concept of natural rate of unemployment, which is a level of unemployment in which prices are stable.

At natural level of unemployment, expected and actual inflation equalize, leading to expectations that inflation remain constant. For Phelps (1967), if the statistically optimum full employment is set as target by policy, inflation will increase above planned. Phelps (1967) explains that monetary policy can be used to increase prices and maintain the level of employment as desired by authorities. Friedman (1968) says that monetary growth stimulates employment and monetary contraction reduces it. The author argues that the trade-off between unemployment and inflation is temporary, not lead by inflation itself but by anticipated inflation.

The effect of unemployment rates different than natural unemployment levels can be seen in the figure below, which we borrow from Mishkin (2012).



Source: Mishkin (2012), Fig. 11.2 pg. 271

Unemployment level below its natural rate forces prices to rise, increasing inflation expectations (Step 1). While such unemployment rate continues, inflation rises continually, shifting the Phillips Curve upwards (Step 2). The higher inflation remains even when unemployment increases (Step 3). Unemployment below its equilibrium level leads to a continuous increase in inflation, which only stabilizes with a return to equilibrium unemployment. Thus, inflationary policy implying increasing employment can lead to a higher inflation than target.

Friedman (1968) critics of Phillips Curve are that it fails to distinguish nominal and real wages. In case of anticipated inflation, nominal wages may rise without changing real wages. The author explains that the Phillips Curve can be well defined for cases in which the average rate of inflation has been stable, since then nominal and real wages change interdependently.

Based on Phelps (1967) and Friedman (1968), the expectations augmented Phillips Curve is:

(1)

$$\pi = \pi^e - w(u - u_n)$$

Inflation (π) equals inflation expectations (π^e) reduced by wages (w) multiplied by employment gap. The last variable is the difference between unemployment (u) and natural rate of unemployment (u_n).

Friedman (1968) and Phelps (1967) suggest no long-run trade-off between unemployment and inflation, when unemployment equates the natural rate of unemployment. In such model, Phillips Curve stops rising when unemployment is equal to natural unemployment. The trade-off between unemployment and inflation relationship is consistent in the short-run, but there is not such relationship in the long-run.

In the 70's, oil shocks resulted in high increase of the prices, thus showing that supply shocks should be considered in Phillips curve analysis. Supply shocks might occur through price changes, such as supply shock that leads to higher costs of production, variation in exchange rate and cost-push, where wages are higher than productivity gains. With inclusion of supply shocks (ρ), the Phillips Curve relationship becomes:

(2)

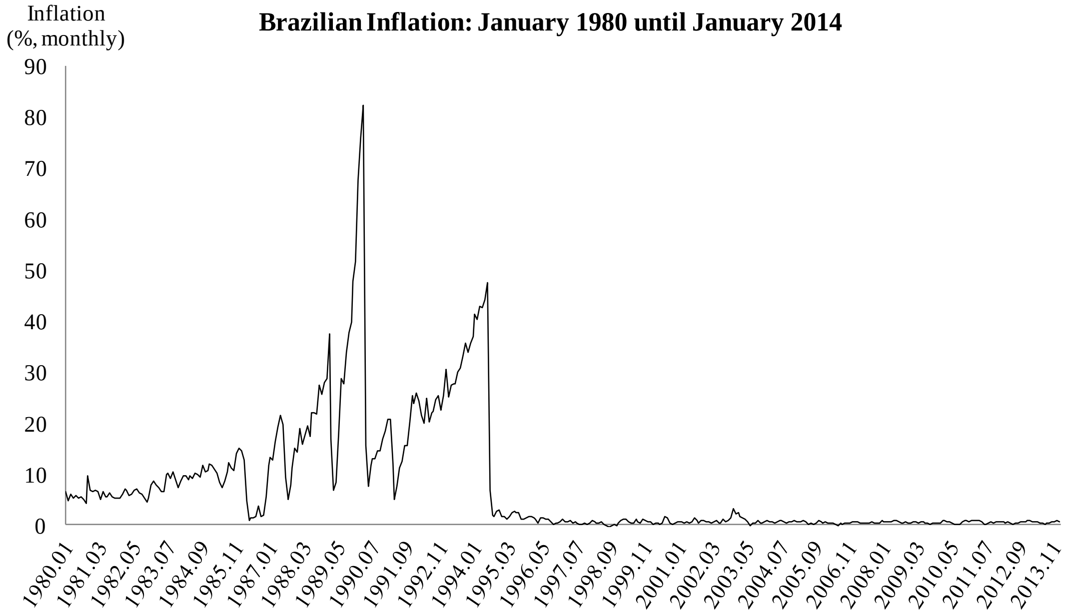
$$\pi = \pi^e - w(u - u_n) + \rho$$

For Mishkin (2012), expected inflation follows a backward-looking behavior, where expectations are based on price change of the last period. For the author, the backward-looking expectations explain price stickiness, as contracts do not adjust to inflation in short run.

Phillips Curve Applications: Brazil

Application of the Phillips Curve to the Brazilian economy was done for different periods and with different variables. Sachsida (2013) offers a review of the literature on the Brazilian Phillips Curve. The author explains that even though the Phillips Curve is highly used by Central Banks around the world, its adequacy to represent the dynamics of the Brazilian inflation has been questioned. Mendonça, Sachsida and Medrano (2012) and Sachsida, Ribeiro and Santos (2009) suggest that it may be the case in which alternative models would be necessary to represent the inflationary dynamics of Brazilian economy.

Reasons for the lack of fit of the Brazilian inflation on the Phillips Curve framework can be related to: high variations in inflation until July 1994, methodological change of the unemployment data in 2002, and to the non-availability of data on inflation expectations until 2000. Graph of inflation in Brazil between January 1980 and January 2014 is provided below.



Between January 1980 and June 1994, average monthly inflation was of 16%, with a peak of 82% that occurred in March 1990. Pereira (1994) explains that the second oil shock in 1979 initiated the fiscal crisis and inertial inflation responsible for high inflation between 1980 and 1994. In 1994, the 'Real Plan', the 13th to be implemented in Brazil since 1979, was able to smooth inflationary levels in Brazil. On its initial phase, to de-index the economy, all economic transactions were converted to the pre-defined index ‘Unidade Real do Valor’ (Unit of Real Value), a non-monetary currency. The month of July 1994 shows stability of inflation. This month coincides with the implementation of the Brazilian Real as the new currency.

In the previous session, we brought Friedman’s (1968) opinion that the Phillips Curve can be well defined when the average rate of inflation has been stable. As inflation stability has not been the case of Brazilian economy before the mid-90s’, we may argue that the Phillips Curve would not be well defined for such inflationary periods.

For Sachsida (2013), main reason for lack of success on the Brazilian Phillips Curve relates to availability of statistics. Methodology of unemployment rate was altered in 2002[1], reason why Mendonça, Sachsida and Medrano (2012) alerted that this series should be carefully selected. Once there are two different series, until 2002, and after 2002, approximations have to be done for studies that include these two periods. Also, inflation expectation series from the Central Bank of Brazil are available since January 2000. The researchers that use expectations for previous periods follow Mishkin (2012), where expected inflation is backward looking, or they have to derive the series.

Variations in inflation until July 1994, change in methodology for unemployment data in 2002 and start of the inflation expectation series in 2000 leaves room for arguing that Phillips Curve estimations should be retried for the period after 2002.

The negative relationship between inflation and unemployment in Brazil has not yet matched the theory, varying on the statistical significance and signal of its coefficient. Portugal et al. (1999) found a statistically insignificant coefficient of -1.745 for unemployment in the quarterly frequency between 1982 and 1998. Filho (2008) finds no tradeoff between inflation and unemployment, arguing that the variables relationship is positive and that the major shocks in inflation in the Brazilian economy have been through exchange rate.

According to Filho (2008), natural unemployment rate calculations have not received much attention in economic literature about Brazilian inflation dynamics. Portugal and Madalozzo (2000) argue that knowledge of the natural rate of

[1] From 1983 until 2002, labor force included individuals from 15 years old on and minimum workload was of 15 hours/week. From 2002, individuals are in labor force starting from 10 years old and minimum workload per week became 1 hour.

unemployment is a need for the economic policy of a country. Filho (2008) estimates, for the period between 1996 and 2006, that natural rate of unemployment was somewhere between 7.4% and 8.5%. Alves and Correia (2013) estimate February 1999 and April 2012 natural unemployment rates as 11% and 6.3%, respectively. These rates are in line with the Central Bank of Brazil's estimate of 6.5% for May, 2012.

Using 1984-1997 quarterly data, Portugal and Madalozzo (2000) estimate Brazilian natural rate of unemployment. The authors' methodology is borrowed from Nishizaki (1997), who uses inflation gap as a function of its past realizations and unemployment. The equation used by Portugal and Madalozzo (2000) is:

(3)

$$\pi_t - \pi_t^e = \propto + A(L)[\,\pi_{t-1} - \pi_{t-1}^e] + \gamma D1 + \varphi D2 + \delta D3 + C(L)u_t + e_t$$

$$e_t = B(L)\,\varepsilon_t$$

Where:

π_t = inflation in period t

π_t^e = inflation expectations in period t

u_t = unemployment in period t

D1, D2 and D3 = dummy variables for changes in inflation expectations

A(L), C(L) and B(L) = coefficients with its respective lags

The dummy variables represent the first and second quarters of 1990, with the implementation of the Collor Plans, and the second quarter of 1994, when the Brazilian currency changed to Brazilian Real.

Portugal and Madalozzo (2000) suggest that with stable economy, inflation and its expectations are equal for any *t*, and unemployment is constant over time. Then, the authors estimate the natural rate of unemployment through the following equation:

(4)

$$u^* = \frac{\propto + \gamma D1 + \varphi D2 + \delta D3 + e_t}{C(L)}$$

For the third quarter of 1997, the authors find natural rate of unemployment in Brazil to be equal to 5.66%.

Another variable used on the Phillips Curve estimations in Brazil is the inflation expectations. We can obtain such data from the daily questionnaire of the FOCUS report from the Central Bank of Brazil, which is available as of January 2000. For Cerisola and Gelos (2005) and for Mendonça, Sachsida and Medrano (2012), the importance of inflation expectations on inflation realizations has increased over the years. Expectations can, according to Mishkin (2012), equal to the realization of the inflation of the last period, known as adaptive expectations. Sachsida (2013) criticizes econometric strategies for calculating inflation expectations as *ad hoc*.

Different proxies have been used to represent marginal cost. Mendonça, Sachsida and Medrano (2012) use, for example, open unemployment of 30 days. Sachsida et al (2009) say that there is no methodology for defining a proxy for marginal cost in Brazilian data.

In the literature on Brazilian Phillips Curve, the proxy usually used to represent the supply shock is shocks in the exchange rate. We may debate the effect of the exchange rate in the Brazilian inflation once imports over GDP in Brazil were 11% in 2013, a slight 2% growth since 2004. Such low percentage does not justify the use of exchange rate as a proxy for marginal cost[2]. Oil and combustibles represented 8.4% of total imports in both 2012 and 2013, reaching 20.2 billion USD in 2013. Even though the frequent usage of oil shock variable on Phillips Curve estimations in international literature, it does not appear as a main factor of influence on Brazilian inflation[3].

III. Model

Based on the traditional Phillips Curve approach and its applications to Brazilian economy, the Phillips Curve relationship to be tested includes inflation expectations, unemployment gap, marginal cost and a shock. Suggested relationship is as follows:

(5)

[2] We carried a tentative estimation of Brazilian Phillips Curve with exchange rate, American Dollars over Brazilian Real, as proxy for marginal cost, being its coefficient insignificant. Such results can be seen the Appendix section. We do not apply such variable as a shock once it has a high correlation, of 0.123 with producer price index series, the proxy for marginal cost.

[3] Estimation of Brazilian Phillips Curve with changes in oil prices as a shock variable can be found on Appendix. As expected, its coefficient is statistically insignificant.

$$\pi_t = \pi_t^e - w\,(u_t - u_{n_t}) + mgc_t + \rho_t + \varepsilon_t$$

Where:

π_t = inflation in period t

π_t^e = inflation expectations in period t

w = wages in period t

u_t = unemployment rate in period t

u_{n_t} = natural unemployment rate in period t

mgc_t= marginal cost in period t

ρ_t = shock variable in period t

From the literature, we presume that expected inflation shall have a substantial and positive relationship with inflation, with values near one. Proxy for marginal cost variable is producer price index (PPI). We select the proxy for shock variable as the credit availability in the market, calculated as the gap between interest rate targets and interest rates.

Calculating the Unemployment Gap

The relationship between the unemployment gap and inflation is expected to be negative. For calculation of this series, we take the difference between unemployment and natural unemployment rates. As there is no availability of time series or consensus of values of natural rates of unemployment in Brazil, we will apply two different series for the calculation of natural rate of unemployment. The first series of natural unemployment is variable and based on Portugal and Madalozzo (2000). The natural unemployment rate of the second series is 6.5% and fixed. We will then use natural unemployment rates for calculation of the unemployment gap.

The first calculation of natural unemployment rate, based on Portugal and Madalozzo (2000), follows the steps:

1. Estimation of inflation gap as a function of past realizations of inflation gap and unemployment rate:

(6)

$$\pi_t - \pi_t^e = \propto + A(L)\left[\pi_{t-1} - \pi_{t-1}^e\right] + C(L)u_t + e_t$$

2. Prediction of residual series of the estimation

(7)

$$e_t = B(L)\,\varepsilon_t$$

3. Calculation of natural unemployment rate:

(8)

$$u^* = \frac{\propto + e_t}{C(L)}$$

In step 1, we run a regression of inflation gap as a function of its past realizations and unemployment and take the error series. For step 2, we estimate the equation from step 1 one more time, with error term as an explanatory variable. In step 3, we assume that in equilibrium, inflation realizations and its expectations equalize, which makes the variables of inflation gap equal to zero. We calculate natural unemployment rate by dividing coefficients of the constant and error variables by the coefficient of unemployment series.

The second procedure for calculating the unemployment gap uses fixed natural unemployment rates. According to the literature review, natural rates should range between 6% and 11%. We will use the fixed rate of 6.5%, value that goes in line with estimations of the Central Bank of Brazil for May 2012.

From the two series of natural unemployment, we calculate unemployment gap as unemployment minus its natural rates. We, then, apply the Phillips Curve model for two equations:

Equation 1: u_n series variable, estimated according to Portugal and Madalozzo's (2000) model.

Equation 2: u_n series fixed at 6.5%.

Results of Equations 1 and 2 will allow us to test if the natural rate of unemployment in Brazil has been variable or fixed for the studied period.

During the analysis of the estimations, we give attention to the properties of the data regarding time series characteristics: trend, seasonality, stationarity, breakpoint; as well as the data regarding the model, distribution, orthogonality conditions and residual analysis.

IV. Data

Variables, Data Sources and Adjustments

Data has a monthly frequency, with a time span between January 2004 and January 2014, a range that provides 121 observations. Below we describe the variables, data sources, and adjustments:

1. Inflation: consumer price index (IPCA), considered the official inflation index by Brazilian authorities. It is a monthly data, provided by the Brazilian Institute of Geography and Statistics (IBGE). The row data was seasonally adjusted[4], is stationary in level and has no structural break[5];
2. Inflation Expectations: taken from the FOCUS research of the Central Bank of Brazil, are the market expectations made on the first working day of each month regarding closing inflation for that same month. Both Quandt-Andrews and Chow breakpoint tests did not accept the null hypothesis of no break on August 2008. Then, we multiplied the series by a dummy variable defining dates before August 2008 as zero. The series was seasonally adjusted, and is stationary in level;
3. Inflation gap: difference taken from the row series of inflation and expected inflation, explained above, and seasonally adjusted;
4. Interest rate gap: a measurement for credit, calculated as the gap between interest rate targets and market interest rates. As Quandt-Andrews and Chow tests pointed a break on May 2008, the row series was multiplied by a dummy variable with

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[4] For seasonal adjustments, we tested the statistical significance of dummy variables related to each month. Then, we reduced the statistically significant ones from the original series.
[5] The technique used for verification of breakpoint tests were Quandt-Andrews unknown breakpoint test and Chow breakpoint test. In both tests, null hypothesis is of no breakpoint.

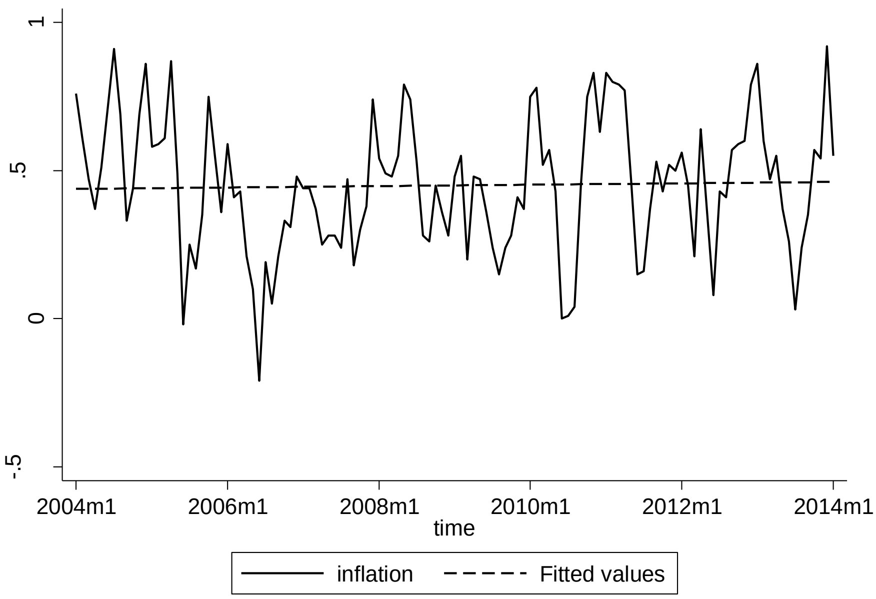
value of one for dates after May 2008. Then, it was adjusted for trend and seasonal effects. It is stationary in level;

5. Wages: data from the Brazilian Institute of Geography and Statistics (IBGE), represents the average nominal income from work, received from individuals with 10 or more years old. The data refers to the metropolitan cities of Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo and Porto Alegre. Growth in wages was seasonally adjusted and is stationary in level;

6. Unemployment: rate of individuals 10 or more years old, disengaged from working activities. The data refers to the metropolitan cities Recife, Salvador, Belo Horizonte, Rio de Janeiro, São Paulo, and Porto Alegre. The series, provided by the Brazilian Institute of Geography and Statistics (IBGE), was adjusted for trend, seasonality and was found stationary in level;

7. Producer Price Index: provided by Fundação Getúlio Vargas, the average cost to producers' series (IPA-M), de-trended and stationary in level.

We provide, below, the graph of monthly inflation in Brazil, between January 2004 and January 2014. Inflation series has no breakpoint during the studied period.



Inflation series has a standard deviation of 0.227, minimum value occurs in June 2006, with a deflation of 0.21% and maximum was in December 2013, when prices increased 0.92%. Mean value of inflation series is 0.449%. The stationarity of the series suggest stability of prices in the Brazilian economy for the studied period.

Unemployment Gap: Calculation of Natural Unemployment

For Equation 1, in which natural unemployment is calculated and allowed to vary, steps were:

1. Estimation of inflation gap as a function of past realizations of inflation gap and unemployment rate:

$$\pi_t - \pi_t^e = 1.334 + 0.305\,(\pi_{t-1} - \pi_{t-1}^e) + 0.010\,u_t - 0.170\,u_{t-1} + e_t$$

(2.100) (0.089) (0.359) (0.358)

Standard errors in parenthesis

2. Generation of error series of Step 1 and new estimation of equation:

$$\pi_t - \pi_t^e = 0.868 + 0.308\,(\pi_{t-1} - \pi_{t-1}^e) - 0.041\,u_t - 0.61\,u_{t-1} + 1e_t$$

(0.030) (0.001) (0.005) (0.005) (0.001)

Standard errors in parenthesis

3. Calculation of natural unemployment rate:

$$u_n = \frac{0.868 + 1\,e_t}{0.041 + 0.061}$$

The calculated natural unemployment rate has mean of 8.5% and ranges from 4.76% to 11.71%. These values are in line with those predicted by literature, which assumes natural unemployment rate in Brazil to be between 6% and 11%. Estimated unemployment rate in May 2012 is 6.57%, close enough to the 6.5% of the Central Bank of Brazil for the same month.[6] For equation 2, we generated one more series. Here, natural unemployment rate is not allowed to vary, being fixed at a 6.5% rate.

[6] Appendix 4 – Natural Unemployment Series shows the estimated natural unemployment series.

Then, we calculate the unemployment gap by reducing natural unemployment rates from unemployment series. Unemployment gap series were multiplied by the first lag of wages. First lag was used once it has the highest correlation with inflation, of -0.125. Level series of wages, or other lags, would not bring statistically significant coefficients when used on the model estimation.

Descriptive Statistics

Summary of explanatory variables and its correlation with inflation can be seen on the table below:

Descriptive Statistics

	Obs	Mean	Std. Dev.	Min	Max	correlation: inflation
Inflation Expectations	121	0.432	*0.146*	0.120	0.910	0.599
w(u-un) - Equation 1	119	0.090	*2.440*	-7.833	15.366	-0.090
w(u-un) - Equation 2	119	0.817	*2.498*	-12.967	7.430	-0.125
mgc = PPI	121	0.003	*0.797*	-1.763	1.851	0.368
ρ = interest rate gap	121	-0.658	*0.023*	-0.702	-0.610	0.056

Inflation expectations, with mean 0.44, varying between 0.12 and 0.91, have a pro-cyclical and lagging relationship with inflation[7]. Formation of expectations can be explained by a backward-looking behavior.

The two variables of unemployment gap had a negative relationship with inflation, -0.09 when variable natural rates are applied (Equation 1) and -0.12 when we use fixed natural unemployment (Equation 2). Standard deviation is 2.44 when based on estimated natural rate and 2.49 when we use fixed proportions.

Producer price index, our measurement of marginal cost, has mean 0.003, minimum value of -1.76 and maximum value of 1.85. In level, it presents a positive correlation of 0.36 with inflation. When compared with inflation, it has a pro-cyclical but more volatile behavior.

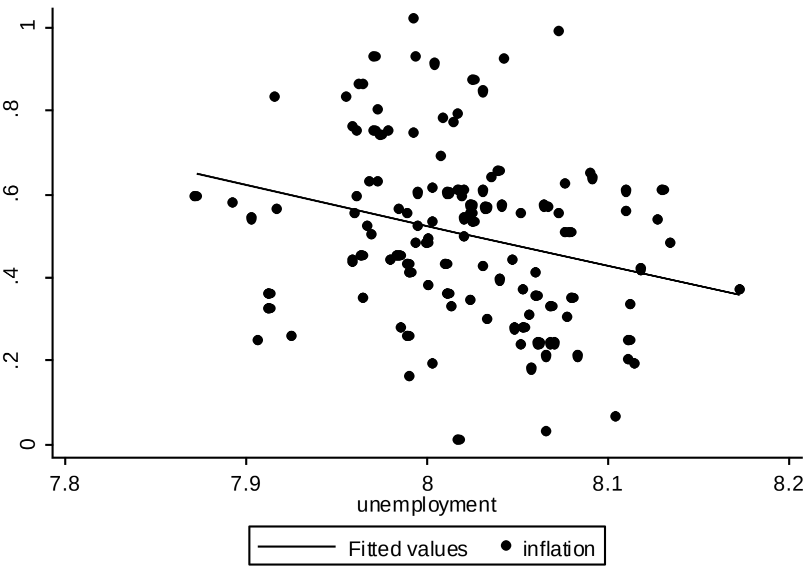
Interest rate gap, the proxy of credit as a shock and calculated as the difference between interest rate targets and market interest rates, presents a positive correlation with inflation, with minimum observation -0.70 and maximum -0.61. Mean is -0.65. An

[7] Graphs of explanatory variables with inflation are provided in Appendix.

increase in the interest rate gap can represent that the market interest rate is cheaper than the target one, which leads to an increase in inflation.

V. Results

In this session, we provide results of the econometric calculation of our model. Based on our calculations, evidence is that Phillips Curve may be applicable to the Brazilian economy during the studied period. In addition, we assess the behavior of natural rate of unemployment. The graph below shows the relationship between inflation and unemployment.



The scatter diagram between inflation and unemployment suggests that, as implied by the Phillips Curve framework, there is a negative relationship between both variables. Here, an increase in employment would lead to an increase in prices and a higher unemployment would be associated with lower inflation.

The results of the model provide evidence of the applicability of the Phillips Curve relationship between inflation and the selected variables, thus indicating that we could apply such framework to the economy of Brazil. We show the estimation results on the table below:

Dependent Variable: Inflation		
	Equation 1	Equation 2
Inflation Expectations	0,845	0,834
	*(0.099)***	*(0.100)***
w(u-un)	-0.012	-0.008
	*(0.006)**	*(0.005)*
PPI	0,074	0,075
	*(0.018)***	*(0.018)***
ρ	0,218	0,234
	*(0.0681)***	*(0.068)***
R squared	91,89%	91,75%
R squared adjusted	91,61%	91,47%
SSR	2,895	2,943

Standard Errors in parethesis
** significant at 1%   * significant at 5%

In Equation 1, with the natural unemployment rate variable, all explanatory variables are statistically significant. The degree of adjustment (R^2) suggests a good fit of our model.

Inflation expectations had coefficient of 0.845 and p-value of 0.00, being statistically significant. Once inflation measurement is as a percent increase, interpretation is that a 1% increase in expectations leads to a 0.845% positive change in inflation.[8]

The unemployment variable $w(u-u_n)$ had, as expected, a negative relationship with inflation realizations, of -0.012. It is statistically significant at a 5% level, with a p-value of 0.049. Insight of this coefficient is that a 1% change in the variable $w(u-u_n)$ reduces inflation by 0.012%. Such changes can happen by a variation in wages, unemployment and natural unemployment. In Equation 1, natural unemployment is allowed to change once it is calculated within the model.

The proxy for marginal cost, producer price index (PPI), is statistically significant with a p-value of 0.0. As, like the previous variables, it is calculated as a

8 If we do not consider the breakpoint, such coefficient is 1.03. Breaking the series reduced the coefficient value of inflation expectations. Estimations without breaks can be seen on the Appendix section.

percentage change, its coefficient represents that a 1% variation in PPI leads to 0.074% positive change in inflation.

In Equation 1, coefficient of the shock variable, interest rate gap was of 0.218 and statistically significant. Here, a 1% increase in interest rate gap increases inflation by 0.218%.

The estimation where natural unemployment rate is calculated provides a R^2 of 91.89% and R^2 adjusted of 91.61%, values which signal a good degree of fit of this estimation.

In order to verify stability and reliability of the estimations, we carried model checking of residuals in Equation 1. The residuals series are normally distributed by 95%, lying between -0.4 and 0.4 and stationary, with rejection of the null hypothesis of unit root of the Dickey-Fuller test. Verifications of autocorrelation and partial autocorrelations were done through Ljung-Box test and autocorrelogram, which shows that residuals and squared residuals lie within the 95% confidence interval, so there is no correlation in the residuals. In terms of distribution, Skewness was of 0.4915 and Kurtosis 0.6784, leading to non-rejection of the null hypothesis of the Jarque-Berra test, of normal distribution. ARCH-LM test was also performed, and a p-value of 0.99 provides the interpretation that the null hypothesis of homoskedasticity cannot be rejected.

Estimation results of Equation 2 provide insight on the relationship of the explanatory variables on inflation and on the profile of the natural rate of unemployment in Brazil.

Inflation expectations, with a statistically significant coefficient, affect inflation by 0.834% when changed. This result is similar to the one achieved in Equation 1, leading to the argument that this series may have a influence on the dependent variable.

The variable of unemployment gap multiplied by wage is the main change between the two estimations. The coefficient of -0.008 matches the theory of a negative relationship between unemployment and inflation. Note that despite the p-value indicates the coefficient is insignificant, a one-sided test suggests the relation is significantly negative. From this, we may argue that the profile of natural unemployment rate in Brazil is variable, following the process used in Equation 1. For robustness of our results, we ran an alternative estimation, with natural unemployment rate fixed at 8.5%. The econometrics results were similar to those of Equation 2, being the coefficient of the unemployment variable, $w(u-u_n)$, not statistically significant.

PPI had a significant coefficient of 0.075. Thus, a change in PPI values leads to a 0.075% change in inflation realizations. This proxy for marginal cost is a contribution of this paper. Even though it was not used in previous literature of our knowledge, it has a statistically significant coefficient.[9]

The shock variable had, in Equation 2, a statistically significant coefficient of 0.234. Therefore, a 1% variation in interest rate gap leads to a 0.234% increase in inflation.

Degree of fit, R^2, is one more time high, of 91.75%, showing that the chosen variables have a high explanatory power on the dependent variable.

Residual checking of Equation 2 is, again, similar to that of Equation 1. The residuals series are normally distributed by 95%, counting between -0.4 and 0.4 and stationary, with rejection of the null hypothesis of unit root of the Dickey-Fuller test. Verifications of autocorrelation and partial autocorrelations were done through Ljung-Box test and autocorrelogram, which shows that residuals and squared residuals lie within the 95% confidence interval, so there is no correlation in the residuals. In terms of distribution, Skewness was of 0.609 and Kurtosis 0.882, leading to non-rejection of the null hypothesis of the Jarque-Berra test, of normal distribution. ARCH-LM test was also performed, and a p-value of 0.98 provides the interpretation that the null hypothesis of homoskedasticity cannot be rejected.

The estimation in which the unemployment gap series was statistically significant was that of Equation 1, with natural unemployment being variable. This suggests that the Brazilian natural unemployment rate was probably not constant on the years between 2004 and 2014. The results give the insight that PPI may be a robust proxy for marginal cost and that the shock variable, interest rate gap, is statistically significant in both Equations 1 and 2.

VI. Conclusion

This study aimed to estimate the relationship of the Phillips Curve framework between inflation and unemployment in Brazil in the monthly frequency between January 2004 and January 2014. Even though inflation has been widely studied by economists and Central Banks, it remains as a central topic in research and has the power of affecting opinions about government policies.

[9] In the alternative estimations, found in the Appendix section, PPI is also statistically significant.

Main conclusion of this paper is that, according to our estimations, the Phillips Curve may be applicable to the economy of Brazil for a certain period of time. Other contributions are on the verification of natural rate of unemployment as varying over time, on the reliability of using producer price index as a proxy for marginal cost, and interest rate gap as a proxy for credit as a shock.

We argued that high variations in inflation until July 1994, change in methodology of unemployment series in 2002 and non-availability of inflation expectations until 2000 could have affected previous trials of Phillips Curve applications to Brazil.

During estimation calculations, we generated two different natural unemployment series. The first was flexible and the second fixed at 6.5%, rate chosen based on suggestion of the Central Bank of Brazil for 2012. Then, we used these series for calculation of unemployment gap. The variable that included a flexible natural unemployment rate was statistically significant, while the variable that used fixed natural rate was not. This leads to the interpretation that the natural unemployment in Brazil was probably variable during the studied period.

Other contribution of this study was on the inclusion of producer price index as a proxy for marginal cost. The statistical significance of such variable provided argument for its consideration as a proxy for marginal cost. The shock variable, interest rate gap, also had a statistically significant relationship with inflation.

The fit of the estimations run in this study provided evidence that we may employ the Phillips Curve relationship to Brazil for the monthly frequency between January 2004 and January 2014. This study's contribution to the literature on inflation and unemployment in Brazil should be matter of continuing research, so that we can verify the characteristics and maintenance of the Brazilian Phillips Curve along the years.

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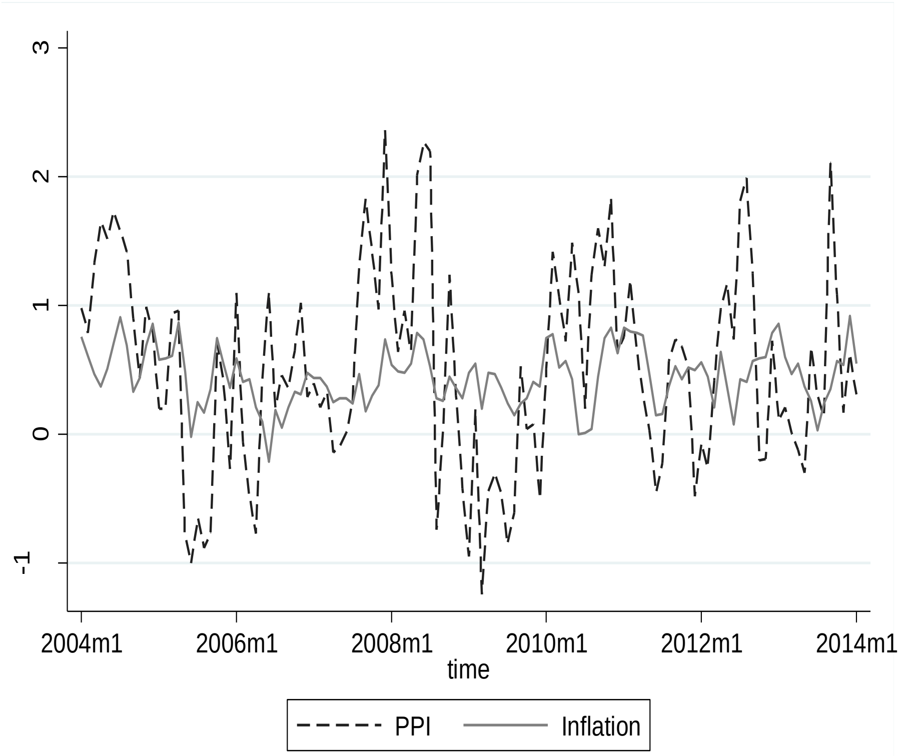
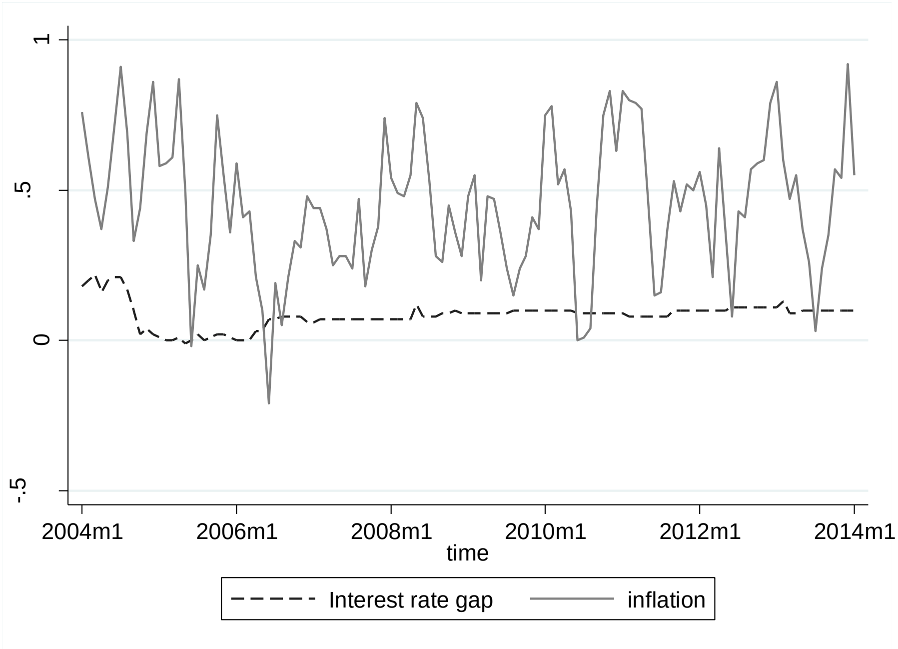
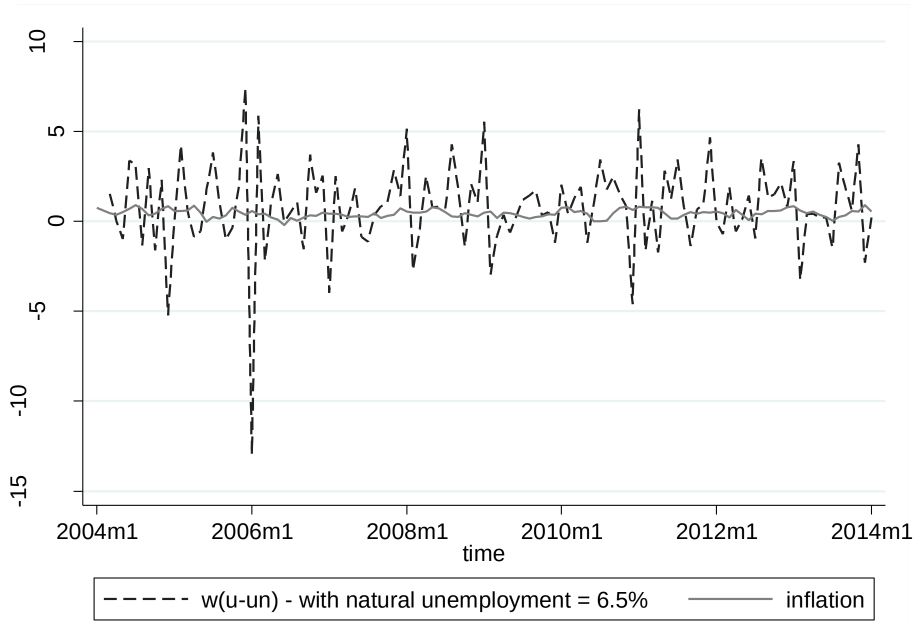
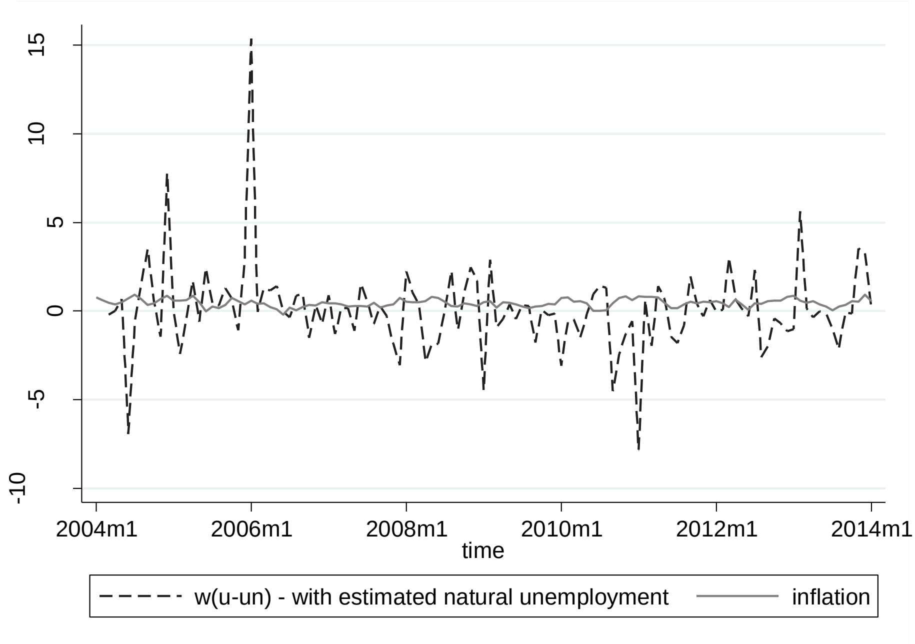
Appendix

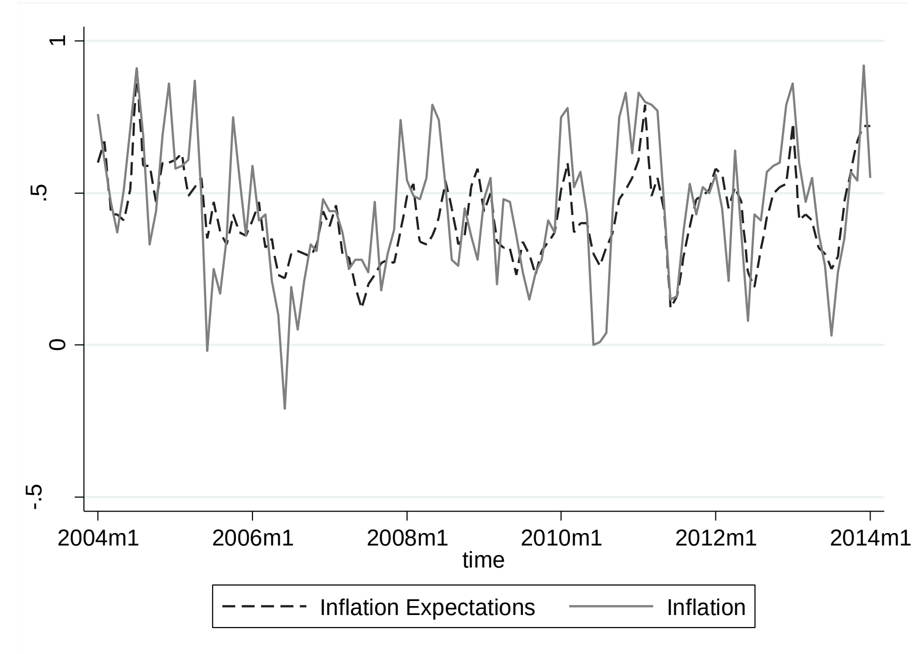
Appendix 1: Graphs: Inflation with explanatory variables




1
.5
0
-.5
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
time
Interest rate gap
inflation


10
5
0
-5
-10
-15
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
time
w(u-un) - with natural unemployment = 6.5%
inflation


15
10
5
0
-5
-10
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
time
w(u-un) - with estimated natural unemployment
inflation


1
.5
0
-.5
2004m1
2006m1
2008m1
2010m1
2012m1
2014m1
time
Inflation Expectations
Inflation

Appendix 2: Alternative Estimation Results

Dependent Variable: Inflation					
	i	ii	iii	iv	v
Inflation Expectations	1,147	1,112	0,97	0,969	0,887
	*(0.033)***	*(0.041)***	*(0.087)***	*(0.087)***	*(0.105)***
w(u-un)	-0.012	-0.013	-0.014	-0.013	-0,014
	*(0.006)**	*(0.006)**	*(0.006)**	*(0.006)**	*(0.006)**
mgc = PPI	0,067	0,074			
	*(0.019)***	*(0.019)***			
mgc = USD			-0.323	-0.336	-0.090
			*(0.143)**	*(0.153)**	*(0.220)*
ρ = interest rate gap					0,155
					(0.111)
ρ = oil shock		0,044		-0.008	
		(0.031)		*(0.033)*	
R squared	91,16%	91,32%	90,61%	90,61%	90,76%
R squared adjusted	90,93%	91,02%	90,37%	90,29%	90,44%
SSR	3,154	3,098	3,352	3,35	3,296

Standard Errors in parethesis

** significant at 1%   * significant at 5%

Appendix 3: Estimations with no breaks

Dependent Variable: Inflation				
	i	ii	iii	iv
Inflation Expectations	1,03	1,059	1,02	1,018
	*(0.062)***	*(0.005)***	*(0.086)***	*(0.086)***
w(u-un) - natural unemployment calculated	-0.013		-0.012	
	(0.005)*		*(0.006)**	
w(u-un) - natural unemployment = 6.5%		-0.007		-0.011
		(0.005)		*(0.006)**
mgc = PPI	0,079	0,079		
	*(0.019)**	*(0.019)***		
mgc = USD			-0.273	-0.378
			(0.174)	*(0.172)*
ρ = interest rate gap	0,577	0,464	-0,182	-0,404
	*(0.302)**	*(0.304)*	*(0.368)*	*(0.358)*
R squared	92,23%	92,00%	91,23%	91,22%
R squared adjusted	91,96%	91,72%	90,93%	90,91%
SSR	2,772	2,854	3,129	3,135

Standard Errors in parethesis

** significant at 1%   * significant at 5%

Appendix 4: Natural Unemployment Series

Time	Natural unemployment	Time	Natural unemployment	Time	Natural unemployment
2004m1	-	2007m6	*10.97*	2010m11	*10.26*
2004m2	*8.10*	2007m7	*8.89*	2010m12	*7.78*
2004m3	*8.33*	2007m8	*11.17*	2011m1	*9.81*
2004m4	*7.48*	2007m9	*6.06*	2011m2	*8.55*
2004m5	*9.25*	2007m10	*8.49*	2011m3	*10.54*
2004m6	*11.29*	2007m11	*9.01*	2011m4	*9.26*
2004m7	*8.30*	2007m12	*11.25*	2011m5	*7.65*
2004m8	*9.87*	2008m1	*7.26*	2011m6	*9.79*
2004m9	*4.76*	2008m2	*8.60*	2011m7	*8.80*
2004m10	*8.45*	2008m3	*9.13*	2011m8	*9.63*
2004m11	*8.97*	2008m4	*9.75*	2011m9	*8.75*
2004m12	*10.22*	2008m5	*11.51*	2011m10	*7.09*
2005m1	*6.79*	2008m6	*11.39*	2011m11	*8.39*
2005m2	*8.80*	2008m7	*7.84*	2011m12	*7.77*
2005m3	*8.92*	2008m8	*7.18*	2012m1	*7.73*
2005m4	*11.09*	2008m9	*7.41*	2012m2	*8.09*
2005m5	*6.32*	2008m10	*9.06*	2012m3	*5.64*
2005m6	*6.02*	2008m11	*6.17*	2012m4	*9.92*
2005m7	*7.75*	2008m12	*5.51*	2012m5	*6.57*
2005m8	*7.46*	2009m1	*9.27*	2012m6	*8.38*
2005m9	*8.35*	2009m2	*9.57*	2012m7	*11.72*
2005m10	*11.03*	2009m3	*6.24*	2012m8	*9.10*
2005m11	*8.78*	2009m4	*10.13*	2012m9	*8.79*
2005m12	*7.35*	2009m5	*9.12*	2012m10	*8.44*
2006m1	*9.61*	2009m6	*10.48*	2012m11	*8.50*
2006m2	*8.01*	2009m7	*7.60*	2012m12	*10.31*
2006m3	*8.93*	2009m8	*7.77*	2013m1	*8.44*
2006m4	*6.36*	2009m9	*8.22*	2013m2	*10.63*
2006m5	*7.19*	2009m10	*7.72*	2013m3	*7.49*
2006m6	*5.84*	2009m11	*8.83*	2013m4	*9.32*
2006m7	*9.24*	2009m12	*7.84*	2013m5	*8.15*
2006m8	*6.77*	2010m1	*10.30*	2013m6	*9.15*
2006m9	*7.58*	2010m2	*10.20*	2013m7	*6.94*
2006m10	*8.73*	2010m3	*8.61*	2013m8	*9.07*
2006m11	*7.74*	2010m4	*9.25*	2013m9	*6.66*
2006m12	*8.44*	2010m5	*7.85*	2013m10	*8.42*
2007m1	*8.31*	2010m6	*6.58*	2013m11	*6.74*
2007m2	*8.85*	2010m7	*7.37*	2013m12	*10.38*
2007m3	*8.57*	2010m8	*6.87*	2014m1	*5.68*
2007m4	*7.48*	2010m9	*9.20*		
2007m5	*9.12*	2010m10	*10.37*		